Towards Adaptive Methods in Finite Element Modeling

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Finite element modeling has proven useful for accurately simulating scattered or radiated electromagnetic fields from complex three-dimensional objects whose geometry varies on the scale of a fraction of a wavelength. Convergence of the simulation can be assessed by uniformly increasing the mesh density until an observable quantity stabilizes. Depending on the electrical size of the problem, uniform refinement of the mesh may be computationally infeasible due to memory limitations. Similarly, depending on the geometric complexity of the object being modeled, uniform refinement can be inefficient since regions that do not need refinement add to the computational expense. In either case, convergence to the correct (measured) solution is not guaranteed.

Adaptive methods attempt to selectively refine the region of the mesh that is estimated to contain proportionally higher solution errors. The refinement may be obtained by decreasing the element size (h-refinement), by increasing the order of the element (p-refinement) or by a combination of the two (h-p refinement). A successful adaptive strategy refines the mesh to produce an accurate solution measured against the correct fields without undue computational expense. This is accomplished by the use of a) reliable *a posteriori* error estimates, b) hierarchal elements, and c) automatic adaptive mesh generation. Various *a posteriori* error estimates have been used in internal region problems in the past. In this paper, mathematical developments of *a posteriori* error estimates developed in structural mechanics and fluid dynamics (M. Ainsworth and T. Oden, *Comput. Methods Appl. Mech. Engrg.*, **101**, 73-96, 1992), and tried in electromagnetic problems (F. Meyer and D. Davidson, *Electr. Lett.*, 30, 936-938, 1994) will be examined for internal and external scattering problems.